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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Highway Construction Machinery

PUBLISHED MONTHLY BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO

LUBRICATION RECOMMENDATIONS

for

HIGHWAY CONSTRUCTION MACHINERY

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Roadbed Preparation
- Power Shovels
- Draglines
- Trenching and Hauling Machines
- Road Graders and Scrapers

Finishing Machinery
- Asphalt Plants
- Asphalt Distributors
- Concrete Mixers
- Concrete Finishers
- Finishing Machines
- Road Rollers

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Oil Lubricated	Same Oil as used in Power Plant

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Lubrication of Highway Construction Machinery

IN a study of the lubrication of certain types of machinery, the utmost consideration must be given to the operating conditions involved. This will be especially true where machinery of comparatively heavy, massive construction is dealt with, for the psychological attitude of the operator must be taken into account. The power shovel, dragline, trenching machine and concrete mixer come under this category.

There has been an ever increasing demand for such machinery since the war, due to the remarkable increase in motor vehicles, and the requirement for highway extensions throughout the country.

The age of the macadam road has practically passed. The asphalt or concrete highway being so far superior, from the viewpoint of durability, as to leave no comparison. The construction of such roads, however, has called for more excavating, and the handling of huge volumes of material, for the route of the modern highway is not governed by the lay of the land. It is planned to follow a definite course, in as direct a line as possible. As a result, we find highways cut directly through chains of hills, with sometimes a huge amount of heavy fill across the valleys.

Unfortunately, interest in highway construction machinery maintenance, however, has not kept step with the progress of engineering and it is frequently found that the operator of the shovel, dragline, concrete mixer, etc., has but a vague understanding of the value of lubricants, carefully chosen and properly applied.

In an effort to give a more complete idea of the importance of lubrication in the operation of materials handling equipment, the following discussion of the problems involved has therefore been prepared.

CONDITIONS OF OPERATION

Highway construction machinery will very frequently be subjected to decidedly intensive conditions which may tend to impair lubrication to a marked extent.

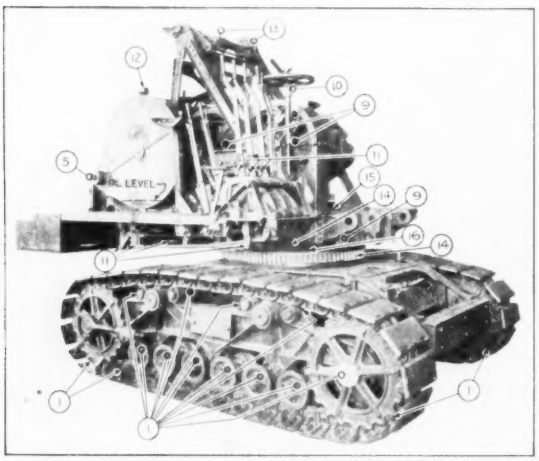
There is considerable difference between the theory and practice of lubrication in connection with such machinery. From a theoretical point of view, certain grades of oil or grease might be expected to function with the utmost satisfaction.

In actual service, however, wide temperature fluctuations, the presence of a considerable amount of dust and dirt, and the possibility of moisture affecting the lubricant must always be considered.

As a result, the operator should not be content with lubricants capable of functioning satisfactorily on more protected machinery. He must take into account the exposed nature of his shovels, draglines, concrete mixers, etc., and the extent to which the construction of their moving parts may be conducive to contamination of the lubricants.

Perhaps the most deleterious condition which may be encountered is the presence of water. It must be borne in mind that moisture,

if present in any appreciable amount, will tend to wash off certain types of lubricating films, if these latter have not been developed by lubricants especially refined and prepared to meet such conditions.



Courtesy of Harnischfeger Sales Corp.

Fig. 1—Lubrication chart, showing the points requiring lubrication on a P. and H. excavator. Among the salient parts are (1), the parts of the corduroy tractor element, (11) the operating lever connections, and (14) the large swing gear.

Dust-Contamination Also Detrimental

The matter of possible contamination of a lubricating film by abrasive foreign matter, such as dust or dirt, should be taken into consideration by the designer, and the moving parts designed as nearly as possible to prevent entry of same. It must be realized that where a bearing especially is so inadequately constructed as to permit the entry of dust or dirt it will be virtually impossible for any lubricant except a heavy grease to prevent the development of wear.

This is brought about by a grease by virtue of the protective collar developed at the exterior surface of the bearing, as the lubricant is injected or works its way through the bearing.

Naturally an oil or a light grease would not develop such protection to the same degree and there would be too much tendency towards dripping from the bearings.

In the case of gears, chains or wire rope, however, but little use of the dust or dirt-tight housing is made. This is, of course, impracticable, due to the very nature of the construction of the machinery and parts involved.

Here, therefore, the lubricant must be relied upon to protect the moving parts as completely as possible against the abrasive effects of foreign matter.

MACHINERY INVOLVED

While the preparation of the roadbed will require virtually the same type of equipment, such as the power shovel, dragline and scraper in order to prepare the foundation and bring it to the proper grade, the type of finished surface, i.e., asphalt or concrete, will influence the types of finishing machinery that may be required.

There are a wide variety of highway surfaces, according to the use which is made of asphalt, concrete and the elementary products, such as crushed or broken stone, sand or paving blocks. It is not the province of this article, however, to deal with such types of highways, nor to discuss their relative merits. Our problem is to investigate the lubricating requirements of the machinery employed.

MANNER OF DRIVE

In the case of materials handling machinery of the type employed in highway construction work, the manner of drive is a criterion.

Steam, in conjunction with the conventional type of reciprocating engine, has heretofore been most extensively used as the means of driving the various elements on the power shovel, dragline or scraper.

Today, however, the internal combustion engine of the gasoline or Diesel type is rapidly coming into prominence. It is furthermore interesting to note that compressed air is being employed in place of steam as a means of driving certain types of swing and crowd engines in shovel and dragline service.

The electric motor has also been adapted to such machinery, but more especially to comparatively stationary installations, such as are involved in mining or stone quarry service. In the average field of highway construction service the use of electric power is still in its infancy.

In a study of the lubrication of highway construction machinery, it is essential to approach it from the viewpoint of the design of the machine, with due consideration for the construction of the means of lubrication and the operating conditions. It must be realized that air, steam, gasoline or fuel oil are quite different in regard to the reaction or effects upon certain types of lubricating oils.

It is hardly necessary to bring this to the attention of the operator. It is, however, advisable to impress him with the salient characteristics which should be possessed by lubricants to most effectively meet his operating conditions, commensurate with the type of motive power involved. These will be discussed in conjunction with the accepted types of construction in use today.

COMPRESSED AIR MACHINERY

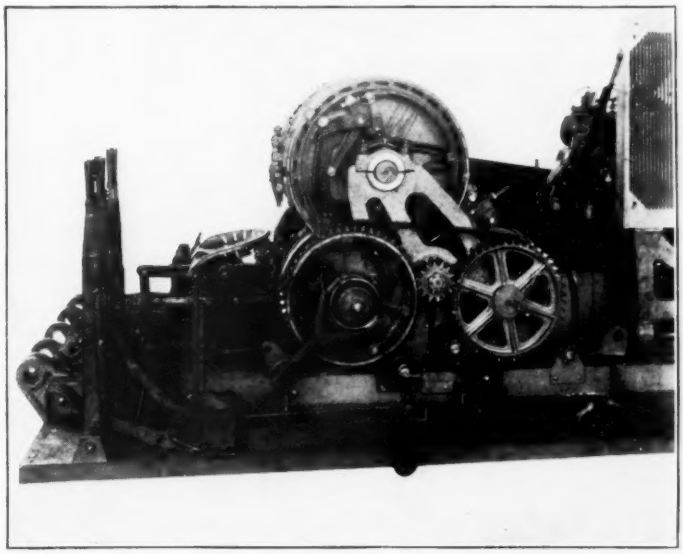
It can generally be assumed that the maintenance of compressed air machinery is directly

dependent upon lubrication, in view of the fact that the use of any oil in excessive amounts, or a product which may have a tendency to develop high carbon residues, may seriously impair the efficiency of the machine.

The use of compressed air as a substitute for steam is a comparatively recent development.

It is possible to use either a Diesel or gasoline engine as the prime mover, the air compressor element being a secondary stage in the power plant. In this way the necessity of providing an extensive amount of space for solid fuel is eliminated.

As a general rule the compressor is of the four cylinder, single stage horizontal type. In the operation of such machines no attempt is made to bring about cooling of the air. On the contrary, to utilize all the energy available, the air as it leaves the compressor is heated by the exhaust gases from the engine. As a result, on discharge from the compressor this air is at a temperature of approximately 400 degrees Fahr.



Courtesy of The Byers Machine Company

Fig. 2—Showing the upper deck of a Byers crane, with cab removed. The power plant of the machine is a Hercules motor. All bearings are lubricated by means of a pressure gun. The large bevel driving gear runs in a bath of oil. All other gears should be lubricated with a comparatively heavy, straight mineral lubricant.

Efficient Operation Depends on Effective Lubrication

Air compressor lubrication will normally be a simple matter provided the oil used has been refined to develop characteristics suited to the operating conditions. It is therefore advisable to have a clear understanding of the relation between these factors. If properly realized maintenance of compressors and the routine of re-lubrication should be one of the most economical and easy jobs on the entire machine.

The essential points to bear in mind when selecting compressor oils are that they should possess adequate viscosity at the operating temperatures and that they show as low a tendency as possible to vaporize and cause accumulation of hard carbon residues.

All mineral oils, regardless of their base or nature, will break down to volatile products and carbon when subjected to heat. The extent to which this will occur, however, will depend on the length of time the oil is exposed to such heat. Consequently, the longer an oil remains within the cylinder, the more carbon can it be expected to develop due to its sluggish characteristics.

On the other hand, analysis of numerous so-called carbon deposits has proven them to consist more of dirt than of carbon, the whole being held together by gummy matter from decomposed oil.

For this reason an oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as instead of vaporizing cleanly it may break down as has been mentioned above, becoming sticky and collecting dirt brought in by the air. The slower the breaking down process, or the greater the volume of oil involved, the more carbon will ultimately be developed.

True carbon may be formed in a hard mass, or it may be produced in the shape of dust and pass out with the air. In the latter case it will often collect in pockets, elbows or on sharp edges and become mixed with dirt taken in by the air as well as with oil which has been vaporized in the cylinder, and later condensed at these points.

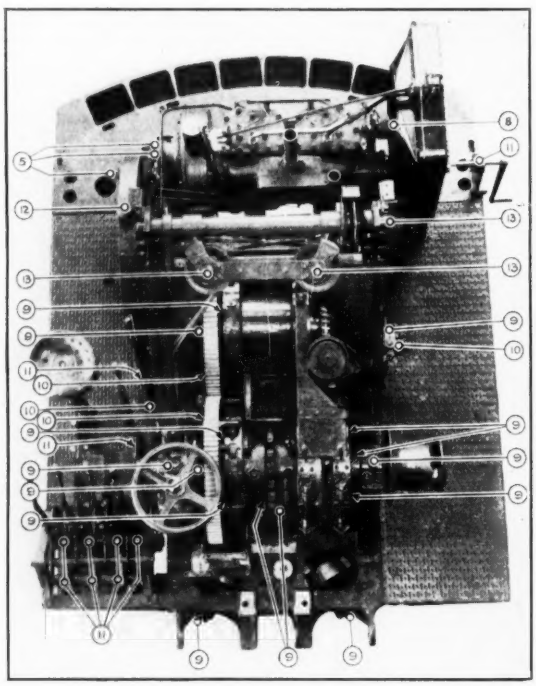
If deposited in the cylinder carbon, being a poor conductor, may become heated considerably above the temperature of the cylinder walls. Not only may this be hazardous, but also, hard carbon especially, is always a nuisance due to the possibility of accumulation on the valves and valve seats, and in the ends of the cylinders. This may cause valves to leak, frequently resulting also in cutting of the latter and scoring of the cylinders.

Pale filtered distilled oils, properly refined, show the least tendency towards direct carbonization and the collection of carbonaceous matter. Furthermore, any such direct carbon that may be formed through excessive use is of a light, fluffy nature. Carbon deposits formed from improperly refined or unsuitable oils, on the other hand, are often of a hard flinty na-

ture. Any oil, however, will accumulate dust if the air is dirty.

Relation of Viscosity

The viscosity of an oil is a far more important characteristic than many will imagine. Upon the viscosity will depend the piston seal that will be obtained, and consequently the efficiency of compression.



Courtesy of Harnischfeger Sales Corp.

Fig. 3—Looking down on the revolving frame of a P. and H. excavator, showing the power plant, the power transmission and speed reduction elements, and the table rollers. The parts requiring lubrication are indicated by Number. (9) in particular shows parts which should be greased once every three hours.

If the oil is too light in body, i.e., low in viscosity, at the operating temperatures in the cylinder it may work past the piston rings to impair the seal.

While an air compressor oil should, therefore, have a viscosity high enough to sustain the weight of the moving parts, and form a proper seal between the piston rings and the cylinder walls, it should never be so heavy as to cause reduction in atomization or involve excessive internal friction.

Moreover, if too heavy an oil is used it will more easily collect any dust that may be present in the air, and will tend to bake on the hot surfaces and form carbon deposits. This is especially likely to happen when more oil has been used than just sufficient to lubricate the wearing surfaces, or where an air cleaner is not used.

It is also important to remember that the pour test must be carefully observed in selecting an oil for air compressor service on highway construction machinery.

Very frequently power shovels are operated at temperatures down to zero and below. It is obvious, therefore, that on starting the compressor oil must be capable of instantaneous flow; otherwise there will be the possibility of abnormal wear on piston rings and cylinder walls. This will, of course, lead to reduction of operating efficiency.

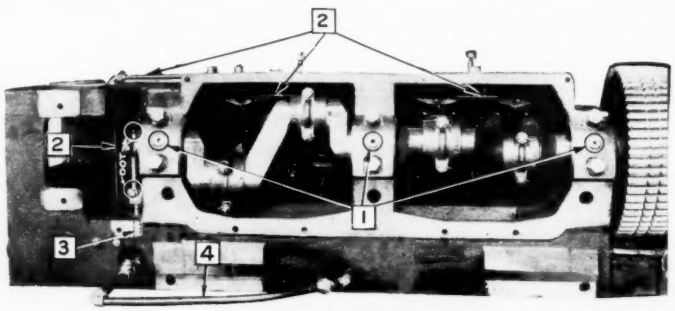
Swing and Crowd Engine Lubrication

In the gas-air or Diesel-air machine, the swing and crowd engines are lubricated by a unique type of hydrostatic lubricator, built as an integral part of the valve chest cover. It is interesting to note, in connection with this device, that the oil feed can be regulated by means of an auxiliary sight feed lubricator. As a result, the delivery of oil can be reduced to the required amount to permit effective lubrication, and yet prevent any possibility of the development of residual deposits in the air lines.

In cold weather operation the oil is kept in a sufficient state of fluidity by means of the heated air in the valve chest.

INTERNAL COMBUSTION ENGINES

The adoption of the internal combustion engine as the power plant in certain types of such machinery has led to the development of a decidedly compact and extremely economical arrangement of the essential equipment. It is important to remember, however, that the internal combustion engine of either the gasoline or Diesel type is of more intricate construction than the average steam engine used for such service.



Courtesy of Bucyrus-Erie Company

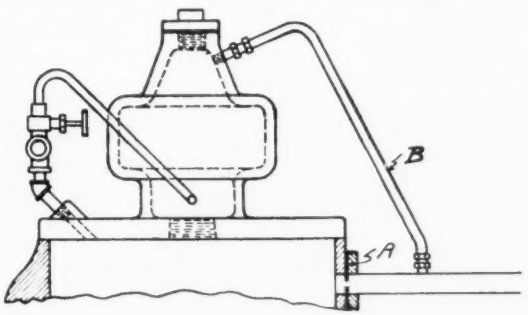
Fig. 4—Exposed crank case view of a Bucyrus-Erie air compressor. At (1) are shown the main bearings of the machine, which receive lubrication from a McCord force feed lubricator. The pipe line marked (2) delivers oil from the pump marked (3) to lubricate the connecting rods. The cylinder walls and wrist pin bearings are splash lubricated. (4) indicates the pipe from the oil sump to the pump.

As a result it requires more care and attention, especially in maintenance and lubrication. Very often the cause of break-down in an internal combustion engine is due to improper lubrication. It is for this reason that every effort has been put forth on the part of the designers to develop a means of lubrication which will be as completely automatic as possible.

In the gasoline type of engine it is customary to have full pressure or a combination of splash and force-feed, the oil being handled by a gear pump, driven by the main shaft of the engine, or, by means of a mechanical force-feed lubricator.

When the latter is used, fresh oil is delivered to the cylinders and main bearings, drop by drop. Such devices overcome the difficulty of possible dilution by furnishing a supply of fresh oil of the right viscosity constantly to each bearing and cylinder. This method of lubrication is very similar to that so commonly employed on many types of Diesel engines today. The oil flow is accurately controlled in its intensity, as well as in its starting and stopping by the engine, since the lubricator pumps are driven by the latter.

It must not be understood, however, that the efficiency of such an engine is solely dependent upon lubrication. Other factors, such as the fuel and its manner of combustion, the grade of lubricants used, the extent to which proper cooling is brought about, and the perfection of the design will all, individually or collectively, affect power development.



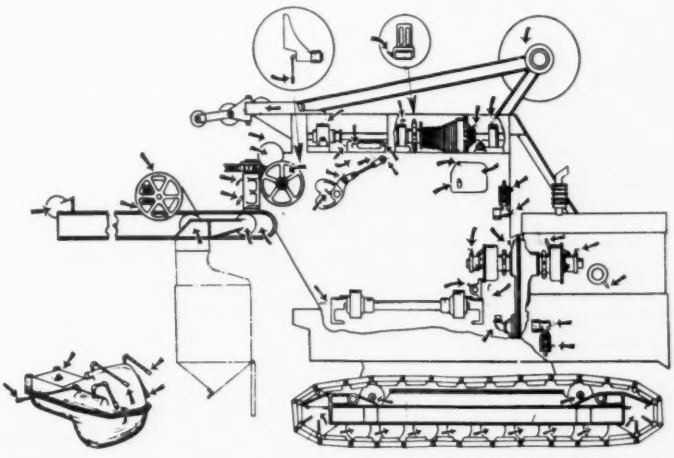
Courtesy of Bucyrus-Erie Company

Fig. 5—The type of lubricator installed on the swing and crowd engines of the Bucyrus-Erie gas-air and Diesel-air machines. The oil chamber is cast integral with the cover. The oil feed is regulated by the sight feed lubricator at the left. In cold weather operation heated air in the valve chest keeps the oil sufficiently warm to insure proper fluidity. This lubricator delivers oil only when the engine is operating. This is accomplished by means of a restriction plate (A) placed in the air supply line. Full line pressure is maintained in the oil chamber through the pipe (B).

As a result, if proper attention is not given to the engine or to the operating conditions, it may lead to reduction of power, and inability of the machine to perform its intended functions.

Gasoline Engine Lubricating Oil Requirements

In view of the fact that comparatively intensive duty is involved in the operation of the average type of highway construction machinery, it must be realized that extremely exacting requirements are imposed upon both the oil and the lubricating system. In fact, certain of these are so important that it is well to discuss them in more detail. A better realization of their importance will enable the operator to understand the matter of lubrication more intelligently, and appreciate its relation to efficient and economical operation.



Courtesy of Chain Belt Company

Fig. 6—Showing a lubrication diagram for the new Champion Rex 27-E concrete paver. Arrows indicate points of lubrication.

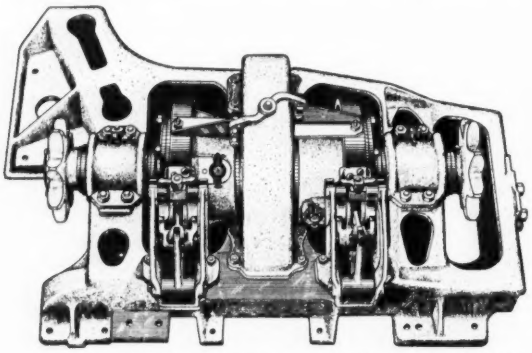
The most important requirements for an oil for this service are as high a degree of lubricating ability as possible, heat resisting characteristics, dependable seal-forming properties, as low a pour test as possible to insure ready flow on cold starting, and sufficient viscosity to enable the maintenance of an adequate lubricating film with the least amount of internal friction.

Lubricating ability, or, as it is often termed, "oiliness," involves the extent to which an oil will be able to develop and maintain a lubricating film between moving parts. The higher this property, the greater will be the insurance against burnt-out bearings, scored cylinders, or the development of wear.

It is also important that an oil for such service should have high heat resisting ability, for this will be an indication of its resistance to decomposition, and the possible development of extensive carbonaceous residue.

From the viewpoint of seal forming, this will involve the extent to which the oil will prevent loss of compression, blow-by of combustible gases, or pumping of lubricating oil past the piston rings.

The pour test is of considerable importance, inasmuch as this characteristic will indicate how the oil will act in cold weather. Obviously, the lower the pour test, or the temperature of relative congealment, the more dependable will



Courtesy of National Equipment Corp., Koehring Division

Fig. 7—View of the base casting of a Koehring paver, showing the power steering parts.

be the lubricating oil. There must be sufficient fluidity to pass readily through the lubricating system and reach the bearings the instant the engine is started, whatever the temperature.

Viscosity, while it has already been discussed, requires consideration from the viewpoint of the extent to which the oil will resist being squeezed out from between any of the wearing parts where pressures may be comparatively high.

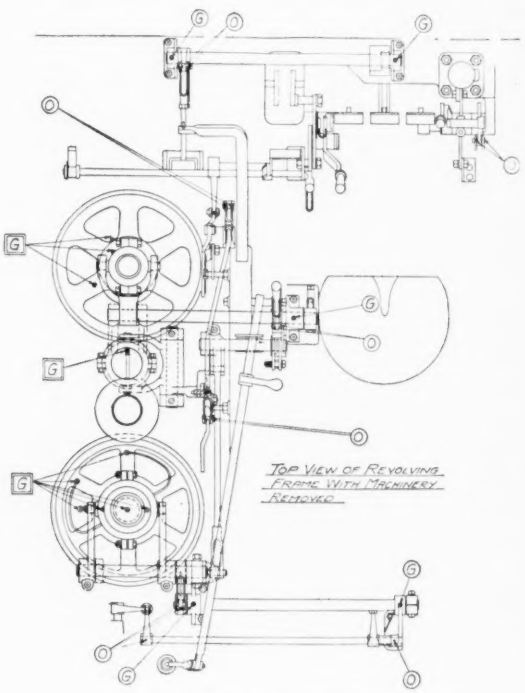
Diesel Engine Drives

Where the Diesel engine is used as a prime mover in such machinery, it is important to remember that successful lubrication will be dependent upon the use of properly refined oil, and the application or delivery of same in sufficient, though never excessive, amounts to the cylinders and bearings by means of a properly designed oil system.

Lubricating Oil Requirements

Regardless of whether a lubricant is to serve the engine cylinders, or is to be used on the bearings, certain basic characteristics are necessary, viz.:

1. It must be so carefully refined as to be able to withstand the usual stresses and strains of intensive service. This requires careful fractionation and effective removal of the lighter components, so that the resultant oil will not be so volatile as to require an undue quantity to maintain a suitable lubricating film, especially on the cylinder walls.
2. It should have as low an emulsification tendency as practicable, due to the chance of contact with water.
3. Furthermore, it must be of such a viscosity or body as to maintain a lubricating film of suitable thickness between the wearing surfaces, under the prevailing temperatures of operation. Yet it should never be so heavy or viscous at these temperatures as to give rise to abnormal internal friction within itself, for this might readily develop excessive operating temperatures, especially on the engine bearings.
4. It should be sufficiently adhesive to resist being squeezed out from between the wearing surfaces when subjected to the normal pressures of operation.
5. It should not congeal, or flow with difficulty, at any of the lower temperatures to which it might be subjected during storage or operation.
6. It should be capable of spreading readily over the surfaces of the cylinder walls, not remaining in streaks or blotches for otherwise suitable sealing of the pistons might be impaired.
7. It must show as little carbon forming tendency as possible, inasmuch as the decomposition which will occur when the oil is exposed to the intensive heat of combustion will in the case of many oils develop a large amount of objectionable carbonaceous residuum. Furthermore, this latter should be capable of easy removal.



Courtesy of National Equipment Corp., Insley Division

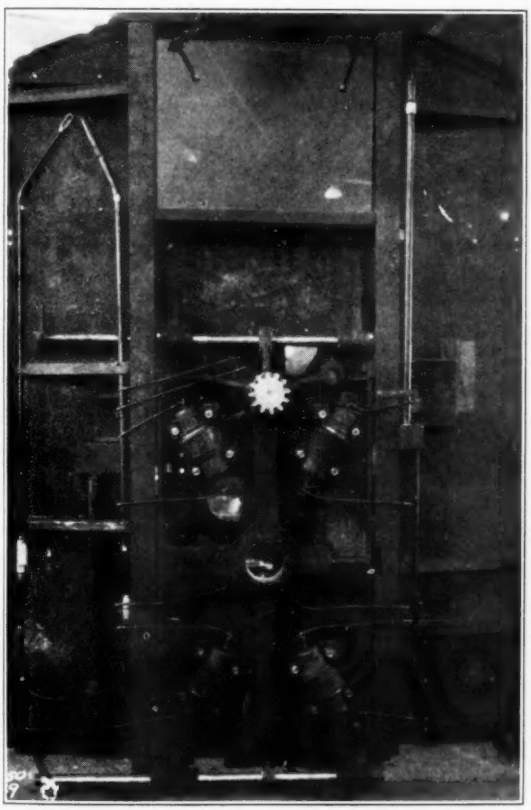
Fig. 8—Showing top view of a revolving frame on an Insley Type R Excavator, with machinery removed. (G) indicates the points requiring grease lubrication. (O) indicates those which should be oiled.

Cylinder Lubrication

Cylinder and piston wear are usually the result of impaired lubrication Cylinder wear may result in loss of compression and reduced power. In other words, an engine with badly worn liners may be unable to carry full load. A most effective way by which excessive cylinder wear can be minimized is by use of proper lubricants as well as dependable means of application.

Lubrication of Diesel engine cylinders will also be influenced to a certain extent by the grade of the fuel and the completeness of combustion.

Experience has shown that lubrication should be positive and uniform, otherwise rings will be worn and may even become stuck, with an appreciable loss in compression. The wrist pins will also be affected. These parts on certain engines will be subjected to relatively high temperatures with but little opportunity for radiation of heat, unless cooled mechanically.

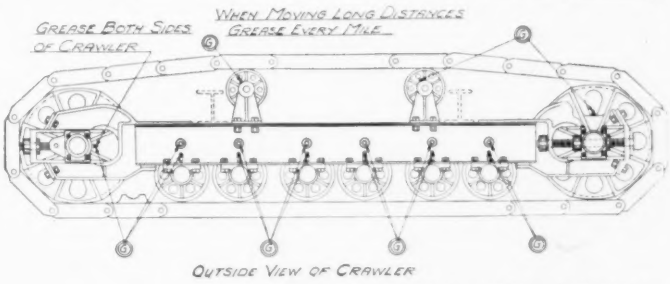


Courtesy of The Marion Steam Shovel Co.

Fig. 9—Showing the means of lubrication installed for the rollers and pinions beneath the upper frame of the Marion shovel. Note the pipe connections and fittings for pressure grease gun lubrication. It is interesting to observe that grease lubrication is provided for all slow moving parts. High speed parts are mechanically lubricated.

Bearing Lubrication

Under mechanically perfect conditions, such as in the case of correct alignment of the main bearings, comparatively little wear will take place in the engine bearings. This is primarily due to the fact that bearings, by virtue of their design and nature of operation, lend themselves to a more effective development of perfect lubrication as a result of more complete separation of the wearing members by a continuous oil film.



Courtesy of National Equipment Corp., Insley Division

Fig. 10—Outside view of a crawler. Note instructions for grease lubrication on the chart. All parts requiring lubrication are indicated by (G).

Lubricating Oil Characteristics

The Diesel engine, as adapted to present day highway construction machinery, is so designed as to be effectively lubricated by the same oil as used for cylinders and bearings.

It is particularly advantageous to use an engine of this type and avoid the necessity of stocking more than one grade of oil for the power plant, for in many localities, the carrying of supplies must be reduced as far as possible.

It is normally customary to use a somewhat heavier oil in warm weather service than under low temperature conditions in order to insure more positive maintenance of piston ring seal and dependable lubrication of the bearings. For temperatures above 20 degrees Fahr. an oil having a viscosity of from 65 to 85 seconds Saybolt at 210 degrees Fahr. will normally be suitable. For temperatures below this dividing line the oil should be somewhat more fluid, of a viscosity range from say 300 to 550 seconds Saybolt at 100 degrees Fahr.

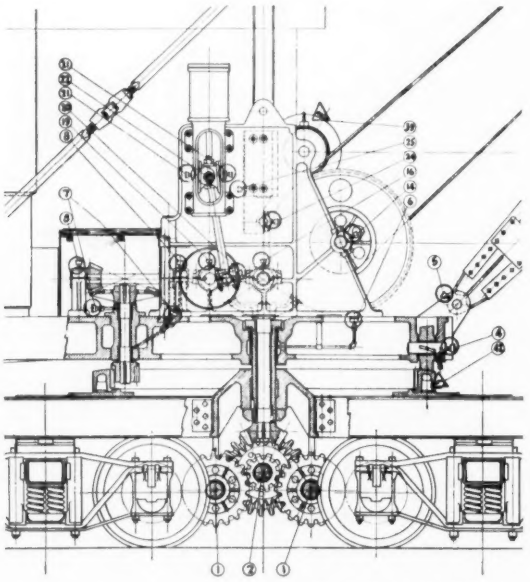
It goes without saying that whatever the grade of oil used, care should be taken to choose a product with a low carbon residue content, and for cold weather service, as low a pour test as possible.

A highly refined, straight mineral product can be depended upon to give positive and effective lubrication and reduce the cost of operation to a minimum.

MOTOR DRIVEN EQUIPMENT

While the electric motor is not as extensively used for the operation of highway con-

struction machinery as the internal combustion engine or steam engine, it should be given consideration from a lubrication point of view, due to the fact that it can be adapted where power resources are available.



Courtesy of The Browning Crane Company

Fig. 11—Diagram of a Browning steam driven crane. Parts indicated by circle show grease or oil cups. Re-lubrication should be carried out every three hours. Parts indicated by triangle should be oiled weekly.

Electric motor lubrication is simply a matter of bearing lubrication. It must, however, be positive and dependable, for any failure may lead to the possibility of the rotor coming in contact with the pole pieces, to cause burn-outs and shut down of the machine. The electric motor is, perhaps, the most delicate mechanism involved in materials handling equipment. Frequently, however, it is given no more consideration than the gears and wire ropes; although these latter, by virtue of their comparatively heavy construction and the nature of their lubrication, are far more capable of standing the duty imposed by temperature fluctuation, and dust, dirt, water, or other contaminating foreign matter.

Such conditions will impose a severe strain on electric motor bearings by virtue of their design and construction, and the normally limited capacity of their lubricating systems.

Bearing Construction

The average electric motor for such service may be equipped with ring oil bearings, or with anti-friction bearings of the ball or roller type. Where the ring oiler is employed oil must always be used as the lubricant. Normally, a straight mineral highly refined product of from 200-300 seconds Saybolt at 100 degrees Fahr. will suffice.

As holds true for the internal combustion engine, such an oil should have as low a pour test as possible, especially where the machine is to be started and operated at comparatively low temperatures.

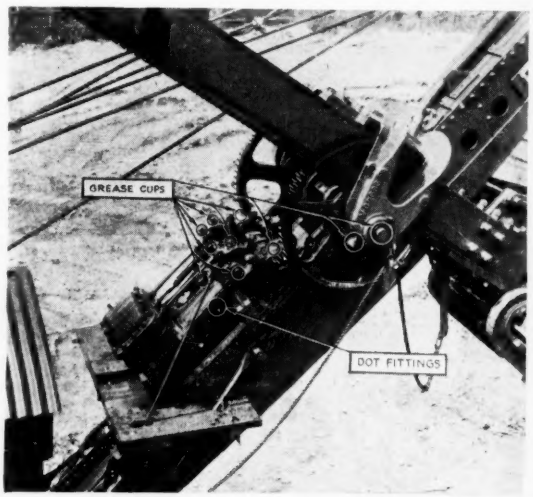
It must be remembered that in a ring oil bearing the amount of heat developed will not be high. As a result, every care must be observed in the initial selection of the oil to insure against congealment or sluggish flow. Otherwise, damage to the bearings might occur, due to actual lack of lubrication.

Where anti-friction bearings are involved, either oil or grease may be used as the lubricant, according to the design of the bearing. As a general rule, oil is preferred where the bearing is capable of retaining the oil supply without leakage.

Greases, on the other hand, furnish better seals against the entry of dust, dirt and moisture.

Grease Requirements

There are certain characteristics which a grease should possess, especially when it is to be used for anti-friction bearing service. Normally it will be essential that it shall not show any tendency to separate in storage or when in action within the bearing. With a properly prepared grease this should not occur even under a certain amount of heating.



Courtesy of Bucyrus-Erie Company

Fig. 12—Showing the boom machinery on a steam driven power shovel. Note that points for grease lubrication are indicated by circles. It is practicable to supplant grease cups with pressure gun fittings. On account of the exposed nature of this machinery, it is essential to pay careful attention to lubrication in order to prevent contamination and wear.

Furthermore, it should show no tendency towards hardening or decomposition, to develop a residue of soap within the bearing, for it must be remembered that soap has a comparatively low lubricating value. There should

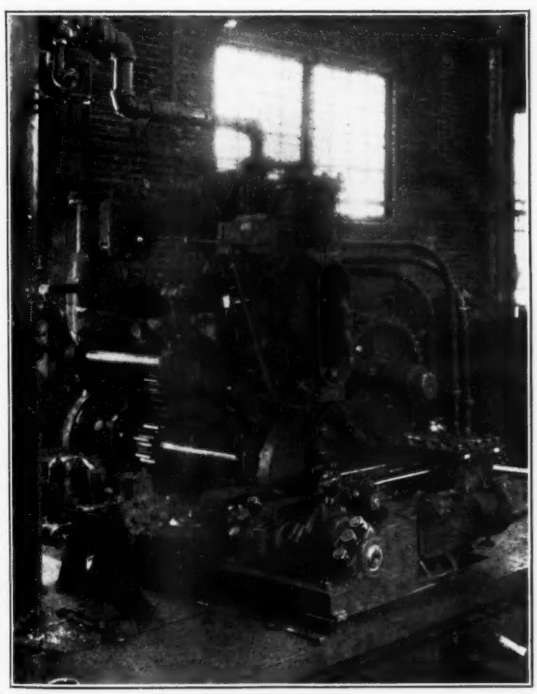
also be no constituent contained in a grease which might lead to corrosion, pitting or rusting of the bearing elements, nor should there be any component which might cause the lubricating film to become sticky or the grease to gum.

Grease for such service should be chosen from the viewpoint of consistency, according to the operating conditions. Frequently a comparatively light product will best meet the requirements, especially if it contains an oil of sufficiently low pour test. On the other hand, there are certain grades of heavier grease which, by virtue of their lubricating ability will serve the purpose equally well, and with but a minimum tendency to channel in the housings or greaseways.

STEAM CYLINDERS

The lubrication of steam driven machinery requires careful consideration of the existing operating conditions.

Steam used on such machines will, in general, range in the neighborhood of 150 pounds pressure; normally it will have quite an extensive moisture content, even though it is taken from the highest part of the boiler. Furthermore, line condensation will be high between the boiler and engines, with a corresponding decrease in pressure, due to the fact that steam pipes are often not covered to any great extent, and the engines are frequently subject to intermittent operation.



Courtesy of The Marion Steam Shovel Co.

Fig. 13—Showing the power plant of a Marion steam shovel. Note the six feed mechanical force feed lubricator installed; also, the compression grease cups on the external mechanism.

As a result there will almost always be an accumulation of water above the throttle valves prior to starting the engines, depending in amount upon the length of time they have been stopped. Now, if the cylinders are not covered with a tenacious film of properly compounded lubricant, the admission of these slugs of water will tend to wash the lubricant from the wearing surfaces, and for the next few strokes insufficient lubrication will be possible and scoring and abnormal wear may occur.

Courtesy of Texas Willite Road Const. Co.

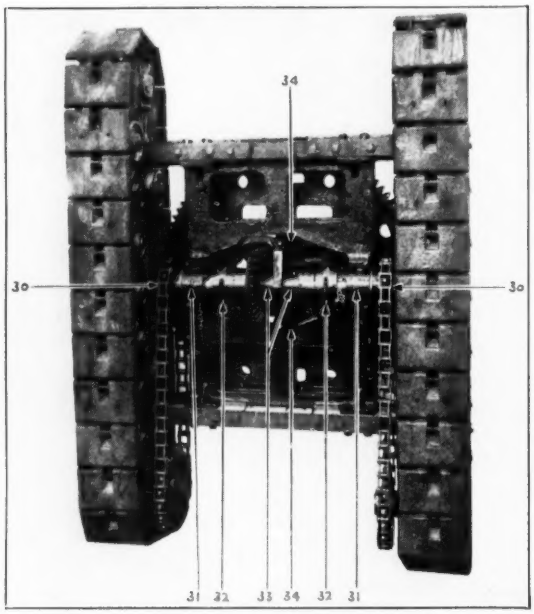
Fig. 14—Showing an Asphalt plant as used in highway construction work. There are certain parts such as gear and chain connections and the bearings of the respective wheels and sprockets which should, by virtue of their exposed position, be carefully lubricated.

The constant repetition of the above will not take long to produce compression losses and inefficient operation of the entire machine, due to steam leakage past the piston rings. Groaning of the engines or rattling of the valves on their seats may also occur in extreme cases.

Point of Introduction Most Important

The point of introduction must be given careful consideration. In general, if this is located at a distance of from six to eight feet above or preceding the throttle valve, unless abnormal conditions arise, atomization can be depended upon to be complete by the time the lubricated steam reaches the throttle valve, and the latter will be quite as effectively lubricated and rendered capable of as efficient operation as the working parts of the engine.

If the point of introduction is located too close to the throttle valve or cylinder, complete atomization may not take place; if too far away there will be a possibility of the oil particles being thrown to the walls of the steam



Courtesy of The Browning Crane Company

Fig. 15—Under-view of a Browning tractor element, showing the exposed nature of the driving chains, gears and their respective bearings. Parts indicated by arrows are pertinent to the travel shaft and gear. They are equipped for pressure grease gun lubrication.

line, from whence a flow of liquid lubricant will occur to the valve chest.

In effect, this might well be termed condensation of the lubricant; it may be quite considerable if there are any bends or other pipe fittings located between the lubricator and the valve chest.

Method of Delivery

In order to lubricate such steam cylinders effectively the oil should be delivered by a positive feed lubricator, preferably of the force feed type, via suitable atomizers. Hydrostatic lubricators could be used were the engines to operate continually, but the usual intermittent service involved would either require constant closing and opening by the fireman, or else a waste of oil would follow if the lubricator were left in service while the engines were stopped.

Where a crowding engine is located on the boom in certain types of these machines, the oil line often enters the steam pipe much further back from the throttle, with the result that in event of steam leaks at the ball or swing joint there will be considerable loss of oil, with subsequent insufficient lubrication unless the leak is stopped.

Types of Lubricants

To meet the average requirements effectively it has been determined that steam cylinder oils must be of comparatively heavy body and have a particularly adhesive characteristic in order to insure the maintenance of a lubricating film which will resist the wearing or scraping effects of the average valve and piston, and washing off by the steam itself.

This will be assured by use of an oil which contains a sufficient amount of high grade animal or fixed oil to promote the formation of an extremely tenacious film of emulsified lubricant, which will adequately resist the washing action of any water that may be present. The base of this lubricant should be a medium viscosity, highly adhesive, steam refined cylinder stock.

Viscosity Essential

Viscosity or body is attainable by suitable refining; adhesiveness by judicious treatment of the so-called cylinder stock by the addition of certain fixed or fatty animal oils.

As a general rule, it will be essential to use an oil having a viscosity range of between approximately 100 and 160 seconds Saybolt at 210 degrees Fahr., according to the steam pressure and temperature involved, the type of steam valves and the means of application available.

Steam the Actual Lubricator

The most efficient way of getting the lubricating oil to all desired points is to make use of the steam itself, which reaches all moving elements inside of the valve chambers and cylinders.

If the oil is divided into minute globules and intimately mixed with the steam, only a very small quantity is required, and the degree of success in the atomization of the oil will control both the efficiency of lubrication of the parts and the quantity necessary.

REDUCTION GEARS

Reduction gears play a most important part in the operation of the power shovel or excavating machine, due to the facility with which they enable the driving of certain of the hoisting elements. There is considerable of a problem involved in the lubrication of certain gears on machines of this type, due to the fact that they are usually exposed, or inadequately housed. There is, therefore, every possibility of dust and dirt gaining entry, to increase the amount of wear and alter the pitch line.

Pressure is generally one of the chief points requiring consideration in a gear installation. As a general rule pressure will be comparatively high due to the small areas of contact. The

more accurately the gears have been cut the more intense will be the pressure, inasmuch as line contact will more nearly prevail.

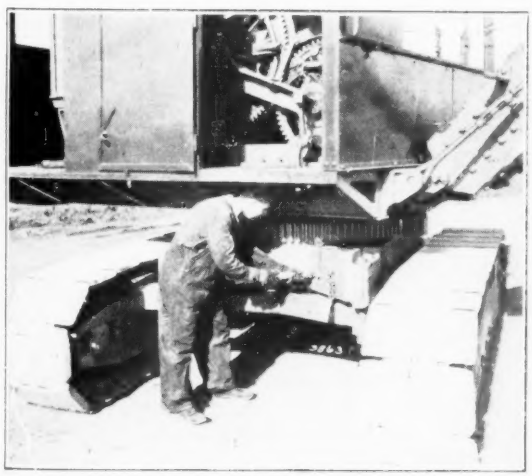
Furthermore, this pressure will be constantly changing, as the gear teeth mesh with each other. This will, of course, change the direction of application of the load. As long as rolling motion predominates, however, the effect on the structure of the teeth will not be serious.

When wear occurs, however, there will be a tendency for the motion between the teeth to become sliding instead of rolling. This will give rise to a certain amount of grinding between the teeth, and bring about wear, especially if lubrication is not maintained in an effective manner.

It is therefore essential that a gear lubricant possess sufficient oiliness to reduce friction to a minimum. This characteristic is dependent upon the viscosity and the ability of the lubricant to adhere to the teeth and resist the pressure which prevails.

It is also essential to remember that the temperature involved should be considered. In the normal operation of excavating machinery gears will function at atmospheric temperature. As a result, the possibility of the gear lubricant being reduced in viscosity by abnormal heating is comparatively remote.

It is, in fact, more important to study the effects which low temperature may have upon a gear lubricant in such service. Certain grades of lubricants will have a tendency to congeal to

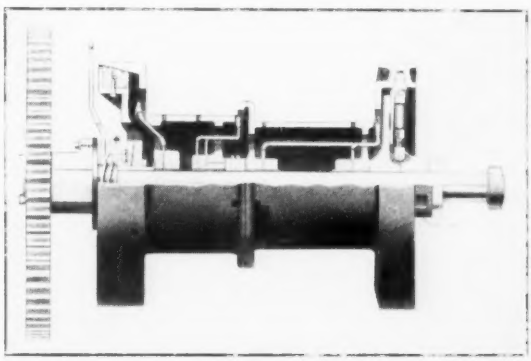


Courtesy of The Osgood Company

Fig. 16—Showing the lubrication of the continuous tread of an Osgood shovel. Copper pipes lead from the high pressure grease lubrication fittings to those wearing elements which are not conveniently accessible.

such an extent as to become brittle and crack. If a lubricant has been properly refined, however, there should be little danger of this occurring.

It has been proven that straight mineral lubricants will generally be best adapted to the operating conditions as mentioned heretofore in this article. The average range in viscosity for service on exposed gears will vary from approximately 600 to 1000 seconds Saybolt at



Courtesy of Industrial-Brownhoist Company

Fig. 17—Showing the details of a hoisting drum for an Industrial-Brownhoist crane. Note the self-closing oilers, which insure lubrication of the drum bearing as it functions in winding or unwinding the wire rope.

210 degrees Fahr., the higher viscosity being more nearly right to meet the usual requirements.

Where gears are enclosed, however, as is the practice in connection with certain types of friction drive machines, the use of chain drives in certain of these installations will require a more fluid lubricant. It must be borne in mind that the average silent chain drive, as employed in this service, will involve comparatively low clearances between the connecting elements which go to make up the links. It is important, of course, that the lubricant be capable of penetrating to all surfaces of contact between these parts; otherwise, abnormal wear will take place. For this reason it will be advisable to use a lubricant of about the same viscosity as a heavy steam cylinder oil, i.e., in the neighborhood of 180 seconds Saybolt at 210 degrees Fahr.

WIRE ROPE

By reason of the extent to which wire rope is employed in the operation of highway construction machinery, it will be advisable to discuss the essentials of wire rope lubrication in considerable detail. It must be remembered that however efficiently the power plant may be operating, the ultimate degree to which the machine as a whole will perform its intended function will depend upon the condition of the cables and wire ropes.

In other words, should a rope have one or two broken strands, due to insufficient or improper lubrication, it might very easily lead to a tie-up of the machine should the ends of the strands interfere with the operation of the sheaves.

This might also involve a distinct hazard, for any wire rope in such condition is weak and more or less incapable of handling the loads to which it is subjected.

The Occurrence of Friction

It is not enough to assume that because wire ropes come from the manufacturers in a lubricated state, being in general wound on an oil-saturated core, that further lubrication is unnecessary.

Under operation there is constant friction and wear between the strands, and a tendency to squeeze out any contained lubricant, especially when the rope passes over sheaves or around drums. The renewal of this product, is, therefore, an absolute necessity.

The matter of friction between the strands of a wire rope is essentially the same as friction between a bearing and a shaft. Overheating and abnormal wear will practically always result, to reduce the load-carrying capacity and increase the amount of power consumed in operation. This can only be overcome by effective lubrication, brought about by the proper application of a suitably prepared wire rope compound which will be capable of not only penetrating to the innermost strands and core of the rope, but also sufficiently adhesive and viscous to resist being prematurely squeezed out or washed off by rain or sleet.

Lubricant Characteristics

Essentially a wire rope lubricant, in addition to the properties mentioned above, must not tend to cake, gum or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it must resist the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. In fact, viscosity in such a product is the essential characteristic involved in purchasing. It should not be assumed, however, as being the chief guide in regard to the actual suitability of a wire rope lubricant.

In this regard the ability of the latter to function, penetrate and stick under actual operating conditions, is of outstanding importance. In consequence such products should not be purchased haphazardly, nor on a price basis alone. The potential difficulties that might result in cold weather are too serious.

According to the operating temperatures that may be involved, and the possibility of the presence of an excess of water, the viscosity of a wire rope lubricant should range from 500 to 1000 seconds Saybolt at 210 degrees Fahr. Where there might be possibility of such a product thinning down to the extent of dripping off to perhaps result in lack of lubrication, it will be advisable to use a lubricant of approximately 1000 seconds viscosity, of course, in accordance with the temperature prevalent.

On the other hand, under relatively cold conditions, it might be advisable to use a thinner product, but again in accordance with the range of operating temperatures involved.

Wire rope lubricants should, in general, be straight mineral petroleum products, devoid of fillers or thickening mediums. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon.

It is for this reason that greases or soap thickened mineral oils are relatively unsuited to wire rope lubrication. To attain the requisite body a comparatively high percentage of soap would be necessary. Soap, of course, serves as the carrying medium for the oil. It has relatively no lubricating value, however; as a result, this property in the resultant product may be decreased to a marked extent. Furthermore, the adhesive characteristic of greases is low. In consequence, such products will not, in general, meet the requirements of wire rope lubrication.

Application of Wire Rope Lubricants

As a general rule wire rope lubricants, by virtue of their viscosity and inertness, must be applied in heated condition. To merely attempt to daub or paint a rope with such a product at normal temperatures would be relatively ineffectual. Even though the surface might be more or less coated, the possibility of penetration occurring to any extent would be remote.

We must realize that this latter is the secret of effective wire rope lubrication. The amount of wear occurring between the exterior of such a rope and the sheaves is not as marked as that which occurs between adjacent strands when the rope is flexed or bent, as in passing over sheaves or hoisting drums. On the other hand, bending promotes penetration of the lubricant.

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